



UNITED STATES OF AMERICA



FOUNDED 1836

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WASHINGTON, D.C.





AN  
ESSAY,



ON THE MINERAL PROPERTIES OF THE

*Sam'l McIntire*  
Sweet Springs of Virginia,

*Feb. 4, 1853*

AND CONJECTURES

RESPECTING THE PROCESSES OF THEIR PRODUCTION  
BY NATURE,

TOGETHER WITH HINTS

RELATIVE TO AN ARTIFICIAL FORMATION OF SIMILAR  
MEDICINAL WATERS.

TO WHICH ARE ADDED,

A FEW CONCISE STRICTURES ON A TREATISE,  
COMPOSED BY JOHN ROUCLLE, M. D.  
ON THE SAME SUBJECT.

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By Doctor John Baltzell.

FREDERICK-TOWN, MARYLAND.

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Baltimore:—Printed by  
WARNER & HANNA.—1802.

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To Doct<sup>r</sup> PHILIP THOMAS, president of the Medical  
and Chirurgical Faculty of the State of Maryland.

SIR,

*The numberless instances of your friendship, unequivocally demonstrated on various occasions, embolden me to present you with the first fruits of my Chemical Lucubrations. Conscious of the difficulties necessarily interwoven with the subject of my Essay, and of my own inability to do it the ample justice it merits ; I beg you to accept of it, as an humble acknowledgment of the many favours, I have received at your hand. A pupillage of four years, under your direction, has enabled me to appreciate your deportment in the various capacities of man and physician, and the distinguished honour which the Medical and Chirurgical Faculty of the State of Maryland have conferred on you, fully evinces the respect and high sense, they entertain for your talents and professional acquirements.*

*The exalted principles, which have suggested and established the institution, over which you preside, do immortal honour to the Legislature of the State of Maryland, and will insure it to flourish more and more, as humanity and science advance. It must be the most cordial wish of every thinking and benevolent mind, that the care of life and health should be wrested from the hands of empirics and unprincipled pretenders to the healing art, to be reposed in the lap of science and confided alone to those who*

are properly qualified by a due course of study in the medical profession. Through the mental imbecillity naturally attendant on disease, how many mortals are deluded by the interested artifices of unfeeling Quackery! How many, duped by artful promises of relief under the writhings of morbid agony, fall victims to medical imposture, and only obtain that relief by an extinction of life! It is the end of your institution, to obviate these evils: it is to such an end your labours are directed: and, give me leave to add, that on so glorious a basis, supported and fostered by the united aid of science and humanity—the superstructure must prove equally useful and beneficial.

As president of this institution you will accept of this Essay, as an unequivocal proof of the high esteem and veneration, I entertain for it and the interest I feel in its prosperity and advancement.

With sentiments of esteem,

Your's affectionately,

JOHN BALTZELL.

Frederick-town, Dec. 22d, 1801.





## An Essay, &c.

A CELEBRATED writer on Chemistry says,  
“ The analysis of mineral waters is one of the most  
“ difficult problems of Chemistry. In order to make  
“ a perfect analysis, it is necessary to be aware of  
“ all the distinctive substances, which may be held  
“ in solution in any water. The *operator* must be  
“ acquainted with the means of separating from an  
“ almost insensible residue the different substances,  
“ which compose it: He must be able to appreciate  
“ the nature and quantity of the products, which  
“ are carried off by evaporation, and likewise to  
“ ascertain, whether certain compounds are not  
“ formed by the operations of his analysis, while  
“ others may be decomposed.” This account of the  
qualifications, requisite to accomplish the chemical  
genius for a complete analysis of the properties of  
mineral waters, would impel one, more hardy, than  
I wish to be, to acknowledge his incompetency to  
such an undertaking; but as commencing this useful  
work in the State of Maryland, where researches of  
this nature have been totally neglected, I feel myself  
animated in the incitement, which this Essay may  
prove to other votaries of chemical science; who,  
fully possessed of those qualifications, are completely  
adequate to the task.

The advantages, resulting from an accurate  
analysis of medicinal mineral waters, must be clearly  
evident and forcibly strike every person who bestows  
a moment's reflection on the subject.

In the first place, such an analysis will prevent the destruction of lives, by pointing out the dangerous consequences of an injudicious use of them.

In the second, by ascertaining their mineral principles, it will serve to improve the method of using them and to obviate the errors committed in their use ; which, no doubt, have occasioned them to fail of their effects in many cases, where they were proper and necessary. And thirdly, it will enable us to discover a chemical process for an artificial formation of mineral waters of similar properties in due proportions and qualities for the use of such valetudinarians, as have it not in their power to travel a distance, to obtain the benefit of the natural mineral waters. These are a few among the many considerations, that might be adduced to enlist philanthropy under the banners of chemistry.

I do not remember ever having seen an account published of the mineral properties of what are called the Sweet Springs of Virginia. They have excited the curiosity of the public for many reasons and particularly for their efficacy in relieving the pulmonary consumption. I have drawn up an account of them together with the method, employed in analyzing them, which I now venture to present to the public. Defective as it may be, I hope, it will afford some general ideas respecting them, and perhaps, animate others, completely conversant in chemical investigations of this nature, to undertake a more correct and minute analysis of these truly excellent medicinal Springs.

The water was conveyed to this place in a bottle well corked, while immersed in the Springs, and further secured with sealing wax, to prevent the ef-

cape of the æriform principles: (It is very limpid and clear, and to my tongue has an astringent subacid taste. Its transparency evinces, how perfectly it holds its mineral properties in solution: I could not discover that it deposited any sort of sediment in the bottle, and observed no discoloration, by which it might be distinguished from common spring water. Several wine glasses were used on the occasion, in which the experiments were separately conducted and the effects of each TEST were carefully distinguished and ascertained. The results were as follow:—

*Exp. 1st.* A few drops of the Muriate of barytes, let fall into some of this water, yielded a white cloud: an infallible evidence, that the sulphuric acid is one of its mineral principles; such is the attraction of the barytes for the sulphuric acid, that the latter seizes the former in whatever combination, it is presented to it, and forms an insoluble compound, called Sulphate of barytes or Ponderous Spar.

2d. The prussiate of lime, being dropped into some of it, afforded the prussiate of iron or prussian blue, with a quantity of rust coloured matter of less specific gravity: this indubitably detects the presence of iron. The prussic acid, seizing on the iron, produces the prussian blue; while the sulphuric acid of the martial vitrol, seizing on the lime, disengages the iron; which, not finding sufficient prussic acid to unite with, falls down in the state of calx or oxide. I suspect also, that some of the carbonic acid gas abandons its union with the iron and makes its escape in an elastic form in this experiment.

3d. A solution of carbonate of potash, being poured into it, produced a white precipitate. This

solution being a test, whereby to discover as well the combination of magnesia with the sulphuric acid, as that of alumine or pure clay with the same acid; we were determined, by our taste, to believe it to be the alum. The potash seizes on the sulphuric acid, while the carbonate of alumine is precipitated. The magnesia turns the tincture of turnsole of a slight green: an evaporation of the water from the precipitate and repeatedly washing it with distilled water, and after calcining it to dissipate the carbonic acid, subjecting it to the test, would ascertain the presence of magnesia, if doubts were entertained as to the alumine.

4th. The oxalic acid, dropped into it, yielded a white precipitate, which demonstrates the presence of lime, as the acid seizes on lime in all combinations forming an insoluble compound, called the oxalate of lime.

5th. The nitrate of silver or solution of silver in the nitrous acid produced a small luna corneæ, like a white cloud in the water; indicating a small portion of muriatic acid or spirit of sea salt united to some base. In this experiment, the muriatic acid seizes the silver from the nitrous acid, on account of a stronger affinity, forming the luna corneæ; while the nitrous acid attacks its base, forming some compound perhaps nitrate of soda.

The foregoing are the fixed mineral properties; which were detected in the manner, we have described; two volatile principles, of a distinct nature and quality, were also discovered to be contained in this water.

*Exp.* 6th. A few drops of a solution of caustic lime, being let fall into it, yielded a white precipitate. The lime is seized by the carbonic acid gas or fixed air, which appears to be in this water in considerable quantity: this precipitate is the carbonate of lime.

7th. By writing on clean white paper, with a solution of acetite of lead or saccharum saturni, and confining it over this water, poured out and agitated in a wineglass, the letters turned of a dark ferruginous hue: shewing, beyond the possibility of a doubt, that it holds, suspended in it, a quantity of the sulphurated hydrogen gas:—The hepatic smell is an additional proof, if it needed any, of the presence of this gas in the water.

If any one be disposed to perform experiments with this gas; he may obtain it, by pouring muriatic acid or any other acid or the hepar sulphuris or liver of sulphur: by this, the solution of sugar of lead becomes an elegant sympathetic ink.

8th. The alcohol of galls, poured into this water produced no change: owing probably to my not employing enough of the infusion or perhaps to the superabundant fixed air in it.

9th. The solution of ammoniac or aqua ammoniæ, which is used to detect copper, mixed with it, without effecting any alteration in the appearance. We had not a sufficient quantity of the spring water to attempt a further analysis, by the process of evaporation; in which case, the fixed saline and earthy principles might have been subjected to tests, applied in different forms.



The accuracy of discovering the mineral properties of waters by re-agents; being called in question by several chemical writers and, this being the only method at present in our power, I thought it necessary to essay this method, by synthesis, in artificial solutions of alum and copperas: I accordingly made a solution of copperas and of alum, in separate phials, and performed the following experiments with the same tests, which I employed to detect the fixed mineral properties of the sweet spring water.

*Exp.* 1st. I poured a part of the two solutions together and, into this mixture, I dropped the prussiate of lime; when a beautiful prussian blue, diffused itself throughout, without yielding any kind of rust coloured precipitate; which circumstance further confirmed me in my reasoning on that experiment and in the persuasion of the presence of carbonated iron ore, in the natural mineral waters.

2d. The muriate of barytes, dropped into this mixture, produced a heavy precipitate, the sulphate of barytes or ponderous spar.

3rd. A solution of carbonate of potash, poured into a solution of copperas, precipitated a ferruginous sediment. but,

4th. being poured into a mixture of the two solutions, it yielded a white precipitate, as it does in the water of the Sweet Springs: this, I was positive, could be nothing else, but the carbonate of alumine.

I have fully stated, in the preceding pages, the experiments and my manner of conducting them: as also the grounds and reasons of my conclusions:

I have endeavoured to exhibit a complete view of the processes of my analysis for the critical inspection, of such chemists, as may be disposed, to examine its merits or improve the method, I employed in conducting it. The striking coincidence of the results of my synthetical experiments with those performed on the natural mineral waters appears to me a strong demonstration in favour of my conclusions; according to which, the water of the sweet springs contains the following mineral properties:

Synon.	
Carbonated iron ore.	Calx or oxide of iron, mixed with earthy principles, dissolved by carbonic acid gas.
Copperas.	Sulphate of iron, martial vitriol, supervitriolated iron, salmartis, green vitriol.
Alum.	Sulphate of alumine, supervitriolated clay.
Synon.	
Fixed air.	Carbonic acid gas, aerial acid, cretaceous acid, gas sylvestre of van helmont, &c. &c.
Sulphated hydrogen gas.	Hepatic gas, sulphurcaline gas or air, inflammable air holding sulphur in solution distinguished by the smell of putrified eggs.
Carbonate of lime, and the	Limestone, chalk, &c.
Muriatic acid	Spirit of sea salt. Marine acid, &c.

united to some earthy or alkaline base, perhaps soda, in a very small proportion: these two last, carbonate of lime and the muriate, are also found in various quantities in the well waters of Frederick Town and,

I suppose, bear no part in the medicinal virtues of the sweet springs.

I would not venture to assert, that these are all the mineral principles, contained in the water of the Sweet Springs: it would require a nice experimental investigation, conducted at the spot, and frequently repeated in every modification; before that could be confidently pronounced: I have confessed my ignorance of the base of the muriatic acid and, in the subsequent part of my observations, I have conjectured, that there may also exist a portion of sulphate of lime or selenite in the waters, on grounds which are there stated. A quantity of the water, conveyed in a bottle holding about two pounds, must have been considerably agitated in a journey of upwards of two hundred miles: the æriform principles would naturally rise in an elastic state, ready to escape on drawing the cork; and we were sure, that part of them did escape, from the whizzing noise produced on giving vent, when it was opened for the purpose of experimenting; consequently, nothing definite could be advanced as to their quantity and proportion in the water, as it is drank at the Spring-head where however these as well as the fixed mineral properties must always vary, according to the quantity of rain that falls, and the humidity, dryness and temperature of the atmosphere. We did not attempt to ascertain its specific gravity, which was omitted as a matter of little importance; since it could not have been esteemed accurate, on account of the escape of part of the volatile principles: and the temperature of the water must be determined by a thermometer immersed in it at the fountain head.



The temperature and specific gravity of the Sweet Spring water was ascertained by J. MADISON, Esq. who communicated an account of the experiments in a letter to Dr. RITTENHOUSE, which was published in the 2d vol. of the transactions of the American Philosophical society of which the following is extracted.

*Exp.* 1st. "Having plunged a very sensible mercurial thermometer in the Spring; it stood at  $73^{\circ}$ :  
"the temperature of air was about  $69^{\circ}$ .——

2d. "A good hydrometer sunk one twentieth  
"of an inch deeper in common mountain water than  
"in the spring."

After the preceding account of the analysis of the waters of the Sweet Springs; may we not venture into the fields of conjecture and risque an opinion, respecting the origin of their mineral properties. On this discovery, must depend the imitation of nature by human art and ingenuity. What should prevent the consequent effects if the causes be presented in equal energy? it is only this, that art requires to rival nature in the production of mineral waters. Such has been the opinion of some eminent Chemists and, in this instance, a knowledge of the formation of the mineral properties of the Sweet Springs, would be incalculably useful. Their virtues have been so often evinced in relieving the pulmonary consumption, a disease extremely frequent in the United States of America. How often does poverty, the debility of the patient and distance prohibit the journey!——The considerations of the immense advantages, redounding from such a discovery, may perhaps induce an enlightened Chemist

at some future period to undertake this arduous and divine task, for the glory and welfare of his country.

If I may be indulged in a little speculative reasoning on the subject, I would say; that a stratum, composed of iron ore, sulphur, alumine or clay and limestone; or in other words, that martial pyrites, mixed with clay and limestone, would impart to water, as it flowed through it, all the medecinal principles; which we have detected in the Sweet Springs, and advance the opinion; that it is to such a stratum, those Springs are indebted for their mineral properties, as it contains in itself every material necessary for the production of them: although not having seen the face of the country nor any fossils, adjacent to them, I must dispense with the best aids, to form a correct judgment on that head. However, I hope my presumption will be pardoned, if, taking for granted, that my conjecture is correct, I endeavour to trace the operations of nature in the production of their mineral properties, agreeably to the principles of modern Chemistry.

The preliminary positions, which I shall here lay down, as a key to unlock the recesses of this mystery! have been established by the experiments of Chemists and are generally received as facts and admitted by all new writers on the subject, who have adopted the *theory* of *Lavoisier*.

Water is a compound fluid, though formerly considered as an element by several Philosophers, consisting of two principles, oxygene or vital air and hydrogene or Dr. Priestley's inflammable air:— with it, is combined caloric or the matter of heat, in a latent state, and a good deal of atmospheric air is

also contained in it; but these are not component principles of the water; they only occasion its fluidity \* and transparency.

The sulphuric acid is produced, by combining sulphur or brimstone with a base of vital air or oxygene; in which a disengagement of heat takes place in a greater or less degree:—Consequently, the sulphuric acid consist of oxygene and sulphur combined.

Hydrogene, the other constituent part of the water, has the property of dissolving sulphur, in which it must be considerably assisted by the heat, that accompanies the production of the acid.

The sulphuric acid separates fixed air from limestone, wherever it comes in contact with it, by seizing on the lime and forming sulphate of lime, gypsum or selenite.

This acid, united to the alumine or pure clay, constitutes alum and, united to iron, it composes the copperas or martial vitriol.

Now to apply these positions, as rules of agency, in the effects, that would result from water coming in contact or flowing through a composition of iron.

\* Note. Mankind have affixed different appellations to the same substance under different modifications: we say vapour, water, snow, ice, &c. which only vary from each other in adventitious circumstances, depending on the different portions of the matter of heat or caloric and atmospheric air, combined with the same substance. Fluidity may be considered necessary to constitute water; but it nevertheless is only an effect of the causes mentioned. Ice, says Chaptal, is the natural state of water.

ore, sulphur, limestone and clay; we will reason thus :

The oxygene of the water, which is decomposed by the iron and sulphur, seizing on the sulphur, forms the sulphuric acid; which has a threefold operation according to the material it meets with, first it produces copperas by uniting with the iron, which, being already oxidized, is more readily acted upon by the oxygene and sulphur: secondly, by seizing on the clay or alumine, it produces alum and, thirdly; by seizing on the limestone, it sets at liberty the fixed air or carbonic acid and forms the sulphate of lime.—Here then we are presented with the etiology of three principles: the copperas, alum, and fixed air.

Hydrogene, the other component principle of the water, in consequence of its disengagement in the formation of the acid with the oxygene, becomes elastic and volatile and, probably assisted by the heat, that accompanies the production of the acid, it would naturally dissolve part of the sulphur or seize it already suspended in the water:—Here then we have the origin of the fourth principle explained: the sulphurated hydrogene gas.

The presence of the limestone and carbonated iron ore may be easily accounted for, by the attrition of the water in its passage through those substances; but the latter, \* being previously in a state of oxide, is afterwards dissolved by the ærial acid it meets with in the water, and of course, only the muriatic acid, united to some unknown base, remains unaccounted for.

\* Note. Perhaps in part by double elective attraction from the martial vitriol and limestone.

According to this hypothesis, if such it may be termed, we must admit the presence of another property in the water, for which we had not a test, I mean the selenite, gypsum or plaster of paris; for it is presumable, that if the preceeding are the processes of nature in the production of the properties of the Sweet Springs; a part of the substance, formed in the disengagement of the fixed air by the union of the sulphuric acid with lime, would also be dissolved in it; being soluble in five hundred times its weight of water, according to Chaptal at 60° of Fahrenheit's.

If some future experiment should detect the presence of selenite, gypsum or sulphate of lime in this water; my conjectures will receive additional probability.

This hypothesis might easily be subjected to the test of experiment, for which, however, considerable resources as well as leisure; which are wanting to me, would be necessary: perhaps some one, possessed of both these advantages, may be induced to attempt it hereafter. From the Chemical phenomena, which we may produce, whenever we please in our laboratories, we have every reason to promise ourselves the wished for success. Let me instance two or three of them: a mixture of iron filings and sulphur, moistened with water, yields the oxid of iron and the sulphuric acid, by the decomposition of the water; while at the same time, heat, sufficient to ignite any combustible material and hydrogen are disengaged. The same mixture, exposed to a certain quantity of atmospheric air in a large glass bell, absorbs all the oxygen, leaving the azote, septic or nitrogen gas undiminished and,



forming the oxide and acid. If the liver of sulphur or fulphurated kali be moistened with water, the hydrogen escapes with part of the sulphur in solution, forming the fulphurated hydrogen gas, while the oxygen of the water, uniting with some of the sulphur, composes the sulphuric acid; which uniting with the alkali, produces a neutral salt. These experiments demonstrate the powerful attraction, a mixture of iron and sulphur have for the oxygen, and further add to the probability of the foregoing hypothesis.

The experiment could be readily performed, by constructing a stratum, composed of iron ore, sulphur, limestone and clay and conducting a rivulet of fresh and limpid water through it.—To imitate nature in the production of those mineral properties, which we have mentioned, it would be necessary to make the stratum of ample extent, to confine it, so as to prevent the immediate escape of the gaseous principles, that would be evolved and to give the water a similar filtration through it, as it is supposed to have in its subterraneous passages, before it reaches the spring head.

After stating my conjectures, as to the production of artificial bath waters, equal to the natural in their mineral properties; I must confess, that I am aware of several difficulties in imitating the processes of nature; which, indeed, appear to me formidable: the manner of constructing the strata of mineral and fossil materials, so as to impart to the perfluent water, the precise principles, in the same quality and proportion, as they exist in the Sweet Spring water, is one of the most insuperable of those difficulties: for after the decomposition of the water

and the formation of the sulphuric acid by its oxygen; the different substances, having different affinities to the acid, the prevailing attraction would suspend all the rest and compose but one of the sulphates, during the presence of the object of that prevailing attraction. In the table of affinities; the lime has a stronger attraction for the sulphuric acid, than the alumine and this latter would displace the iron for the same reason: it follows of course, that if those materials existed intimately combined in the stratum, through which the water flowed; as long as calcareous earth formed a part of the composition, the alum and copperas could not be produced and, after all the lime were seized on by the acid, the clay would still prove an impediment to the formation of copperas or the sulphate of iron.

Nature does not compound her materials into bodies by any laws definitely known: it is evident to us from a view of mineralogy and lithology, that she employs various matrices and mineralizers for the same metallic and fossil substances: she hardly ever intimately combines them in the same modes and proportions; but frequently retains some of them, while she dismisses others in the composition of the mass: thus seemingly capricious is she in the arrangement of inanimate matter and in this operation she particularly eludes the efforts of art.

It would, therefore, perhaps be more advisable to construct distinct strata for the production of each different principle, that might be influenced by the action of affinity; than to risque the production of the mineral properties on a promiscuous deposition of the fossil materials: in this instance, it would consequently be necessary to form three dis-

ferent compositions: one of iron and sulphur or martial pyrites: the second of this and alumine or clay, and the third of iron, sulphur and calcareous stones to develop the fixed air: each of which should be intimately compounded: over these there should three distinct streams of water be conducted properly delayed and percolated, so as to afford every advantage and opportunity for a due impregnation of that fluid with the principles, that would be evolved in each stratum by its decomposition. This latter process would also put it into the power of the Chemist, to diversify the mineral properties of the water in their qualities and proportions; which might perhaps be esteemed a considerable advantage in the eye of medicine. The waters flowing through the separate strata should be made to descend down the same subterraneous declivity in order to be agitated and mixed together before they reached the general reservoir, whence they should issue into an ample cistern for the use of valetudinarians. I thought proper to retain the iron ore in each of the compositions of the strata, as it is found by experience to promote the decomposition of water.

After all, that has been said; it must be confessed, that experiment would alone be the proper guide: for nothing definite can be laid down a priori on such subjects, as so many incidental circumstances influence the manipulations of the Chemist. The quality of the fossil matters, the temperature of the weather as well as water, the properties, which the water imbibed from the soil, through which it flows, and the space of time it continued in contact with the iron ore, sulphur, alumine and limestone, together with the degree of the confinement of the volatile principles, would constitute essential points



of consideration, in the artificial formation of medicinal waters.

The preceding conjectures, respecting the ætiology of the mineral properties of the Sweet Springs and, the suggestions, for a complete imitation of nature in the production of artificial bath waters of similar virtues on an extensive scale, I hope, will not be rejected; before they be thoroughly sifted and investigated. Some perhaps may precipitantly denounce them as the excentricities of a juvenile brain or the utopia of a speculative theorist; but certain I am, that the reasoning made use of on the occasion is founded on an actual observation of Chemical phænomena and, altho' the devotees to phlogiston would condemn my language, they must necessarily admit the facts, I have adduced in support of my observations.

Nature has scattered the greater part of the fossils, required to put such a plan into operation in vast profusion throughout the United States, and if it succeeded, how inestimably happy and beneficial would be the consequences! Every Town or State could be enabled to supply their cachectic and consumptive patients with these salubrious waters, at a small expence, through the united aid and contributions of charity and humanity.

Artificial bath waters of the mineral properties, detected in the Sweet Springs, perhaps might be produced, in the small way, by a more expeditious process of the laboratory. Would not a solution of alum and copperas, properly proportioned, in a certain quantity of clear and limpid water impregnated with ærial acid, by passing through Parker's

apparatus; to which the sulphurated hydrogen gas should be added by the ingenuity of a practical Chemist, constitute an artificial mineral water of the same medicinal virtues as the natural? To have the advantage of oxide of iron ore, held in solution by the water would it not be advisable to employ for the purpose natural chalybeate water or such made artificially? These queries can best be answered by experiment.

However before this plan could be successfully executed, it would be necessary to ascertain the proportions of the substances to be dissolved by a nice calculation of them in a given volume of Sweet Spring water; it would also perhaps be necessary to find out; whether it would be more expedient to introduce the carbonic acid and hepatic gases at the same time, or separately in succession; and with which it would be most proper to impregnate the solution. \* If all these points were well determined by repeated experiment, we then might pretend to rival nature even in our laboratories, for which this process is well adapted; while the other predicated from a plan, established on the original formation of the mineral properties by nature and on a more extensive scale of utility, would require for its execution, the munificence of a state or city.

Since nothing certain can be pronounced, respecting the results of any chemical operations; be-

\* Note. These gases may be introduced into the water at the same time by mixing chalk and liver of sulphur in Parker's apparatus and pouring diluted sulphuric acid or vitriol over the mixture: but in this manner, their proportions cannot be managed: they may be produced separately from these substances by means of the acid in which case they can be introduced in any proportions.

fore they are repeatedly subjected to the test of experiment, which must finally determine the merits of all our speculations on this subject I feel great diffidence in presenting this essay to the public.— I do not pretend to perfection in my performance and, from the intricacy of chemical affinities, which constitutes the sublimest part of hermetic science, it is possible that fallacies may have crept into the deductions, I have made on the subject of my analytical research: however I am not aware of any and, if such be discovered by an ingenious critic, I shall gratefully acknowledge the favour.—With reverence and awe, I approach the fane of science, fearful, whether I be a welcome votary: my offering, I present on the altar and await my sentence, in patient silence.

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### Postscript.

SINCE writing the preceeding account of the Chemical analysis of the mineral properties of the Sweet Springs, I have met with a treatise, composed on the same subject by John Rouelle, M. D. from Europe, which was published in the year 1792, at Philadelphia. I have given it a repeated diligent perusal and find that, not totally liberated from the embarrassments of phlogistic Chemistry, he had to combat an unconquerable obscurity in the explication of his Chemical experiments. He tested all the noted medicinal Springs of Virginia: his analysis of the Sweet Springs appears to me the most unsatisfactory in his whole treatise, as it affords not

the most distant inference for an artificial production of the mineral properties of those waters. His account differs in a great measure from that drawn up in the foregoing pages: I have therefore taken the liberty of examining it, on the principles of pneumatic Chemistry.

Doctor Rouelle's attempts in the liquid way for detecting the mineral properties of the Sweet Springs are very imperfect and superficial: he employed seven tests and for their Chemical results, he does not even venture an explanation; however as he laid little or no stress on the method of analysis by re-agents, depending chiefly on evaporation of the water for the discovery of its fixed mineral properties: it is the latter I consider the principal subject of attention.

Doctor Rouelle began his processes, by evaporating twenty two quarts of the Sweet Spring water in the *balneum maris* or hot water bath, when there first appeared on the surface a "thick pellicle" after the escape of a gas, which he ascertained to be the ærial acid, of which very little more was disengaged; after the formation of the pellicle: this broke and subsided to the bottom.

A similar phænomenon takes place, if a solution of caustic lime be exposed to the atmospheric air, by attracting the carbonic acid, afloat in it, and forming carbonate of lime: the opposite of this happens in the formation of the pellicle by the evaporation of the water; for the acid, instead of being attracted, flies off.—it is thus accounted for: although the caustic lime has a powerful affinity to the fixed air; yet it can retain, but a certain portion

in union with it and whatever is beyond this point of saturation, will escape. The fixed air aids the water in the solution of the lime and, as soon as this abandons it, the water is left alone to act on the solubility of the carbonate of lime (and probably other earthy substances, &c. with it) of which, consequently, the undissolved portion is precipitated.

When the quantity was evaporated to a quart; a yellowish colour appeared:—This, he thinks, is probably owing to the iron, contained in the water. I am of opinion, agreeably to my experiments, that it is partly owing to the carbonated iron ore and, in part to the copperas: the water still retains an acidulous taste, which, he supposes, is owing to a “portion of ærial acid in a true combination with iron and a little earth. This is the reason, why it appears a little turbid and whitish.” I cannot admit, that this acid taste was occasioned by the carbonate of iron, as he thinks: is it not evident, how readily the fixed air abandons the iron, from the ochreous depositions of acidulous chalybeate waters, and is it presumable, that the iron would retain it in such a supersaturated state, as to yield an acid taste after an evaporation of twentytwo quarts to one quart, in boiling water? \* The part falling to the bottom and sticking hard to the glass vessel, some experiments proved to him “to be rather the calcareous mephite and a very little selenite.”

When the evaporation was carried to a sufficient point, he took the whole residuum and put it into a bottle, to take along with him, to try more

\* Note. When the evaporation was continued he says “it went off entirely,” but what was its taste then? was it astringent?



experiments at home: when he opened it, he says, "it smelled a good deal of rotten eggs, stronger than it was at the springs: and a bottle of the Spring water had hardly any smell, but was acidulous." This hepatic odour, undubetably proves the presence of the sulphurated hydrogen gas; but he feels great uncertainty on the subject and observes: "However *I* would not persuade *myself* that there is no hepatic air because sulphur is to be found there in plenty enough, to give suspicions of it. But these particulars belong more to other researches." Modern Chymistry readily unfolds the enigma, by tracing the origin of this gas, to the decomposition of water and the solution of sulphur in the hydrogen.

He now evaporated this to dryness and redissolved the residuous substances in distilled water.—On a new evaporation to a degree of crystallization, the solution "was of a brown colour, making no kind of effervescence with acid or alkali and forming no precipitate, which were proofs, that the salts were perfectly neutralized." It is to be lamented, that he had not an opportunity of observing the results of muriated barytes, prussiate of lime or carbonate of potash, employed as tests in this solution; which would have thrown great light on its contents.

This solution was now evaporated to dryness "the crystallizable salts apart—if we add an acid, there is an effervescence and something remains untouched; with the vitriolic acid, there is a solution of calcareous earth and what remains, is a little of vitriolated tartar and filiceous earth." The effervescence is, undoubtedly, occasioned by

the escape of a gas. What are his proofs for the vitriolated tartar? is it produced by the acid employed in testing? "something remains untouched" is this the filiceous earth or the fulphates of iron and alumine? for these alike elude the action of the acid.

"The chrystals obtained" he further says "are evidently epsom salt or vitriol of magnesia and some chrystals of a marine salt," this last I admit as proved by the luna cornea, formed by the nitrate of silver: the other, I cannot admit as the figure of the chrystals are here of no avail to determine its presence: he also says "I followed the way of distilled vinegar to dissolve the calcareous earth and make a foliated earth, &c. the liquor, being evaporated afterwards, gave no chrystals and is thick:—Then on precipitating it, it is found to be magnesia, which was in the water in perfect combination with ærial acid." Here we observe, he asserts the presence of magnesia without offering any evidence for it. Elleot on bath waters, when speaking of the analysis of mineral waters by evaporation, remarks; "the basis of salts, compounded of the vitriolic acid, may be distinguished by the figure of the chrystals; except natron and *magnesia*; but the latter" he adds "renders lime water turbid: the former does not." The Doctor has advanced conjecture alone for the presence of magnesia and, if we are allowed to judge, by the processes, he has recited, employed no experiment to ascertain, that the water contains it, as he says "in perfect combination with the ærial acid:" it is therefore, in my humble opinion, an inference grounded on mere supposition.

After this succinct view of Doctor Rouelle's analysis of the Sweet Springs, I am inclined to think it defective and unsatisfactory, destitute of the philosophical precision, which ought to characterize researches of that nature——of this, he himself appears to have been fully conscious; when he concludes by saying: “hence it follows that the acidulous spring in Bath County (meaning the Sweet Spring) contains in the quart:

Of Saline substances in general	12 to 15 gr.
Earthy substances	18 to 24
Iron	1 to $\frac{1}{2}$

thus noting down the fixed mineral properties in the undefined generical terms of saline and earthy substances and iron, which cannot afford the most distant hint for the artificial formation of similar medicinal waters. Although from the account of the Doctor's analysis, it does not appear, that he even surmised the presence of alum and copperas in the Sweet Spring water; yet none of his experiments tend to refute or invalidate my inferences from the results of my chemical tests: the observation, cited before respecting the turbid and whitish aspect of the water after considerable evaporation, suggests to my mind a suspicion, that it was occasioned by those two substances and, he also says: on opening the bottle, that contained the residuum, left from the first evaporation, it was quite black; “the end of the cork of the same colour, and covered with small chrystals:” he does not inform us, what these chrystals were.—To ascertain what effect a solution of copperas would have on a cork; I laid one in a solution of it for some hours, when it turned black in like manner: the acid itself has a similar effect, as



may be seen in phials containing it, being injudiciously stopped with corks.

His remarks on the fossils of the mountain, whence the spring issues; prove a strong support to the opinions, I have ventured to maintain in the preceding essay, relative to the etiology of the mineral properties of the Sweet Springs. He observes “each side of the mountain is covered by free stone, some other parts are a kind of jasper variegated with white lines, and the basis of the whole mountain is a hard earth, composed in general of clay and limestone, in different proportions, mixt with iron and coloured by it,” and probably an actual examination would discover the sulphur in subterraneous strata intermixed with these substances: which in my opinion, would evolve and impart to perfluent water the mineral properties, discovered in the Sweet Spring water, by our chemical tests. Agreeably to his analysis, the Doctor admits the presence of selenite or gypsum in it, which I had conjectured a priori in pursuance of my hypothetical reasoning on the subject of the original principles of its production, before I saw this treatise: he also admits that the “sulphur, spread in pyrites as well as in rotten wood, is constantly operating new compositions and decompositions, with all the substances it has attraction to.”

To have my theoretical conjectures so well supported and corroborated with facts by Doctor Rouelle, a Chemist of no common fame, who was on the spot and viewed the face of the country and examined its fossils with judicious attention, free from speculative prepossessions; affords a powerful additional proof, that my Hypothesis, respecting the natural origin

of the mineral properties of the Sweet Springs and suggestions for the formation of similar medicinal water by artificial means, merit at least a candid investigation; before they can be authoritatively denounced as chimerical.

*F I N I S.*





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